EVALUATION OF A SUMMER ENRICHMENT PHYSIOLOGY COURSE FOR MATRICULATING MEDICAL STUDENTS

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A summer enrichment physiology course for matriculating medical students has met a number of short-term goals, including bringing the students to the level of average medical student performance by the end of the summer. The long-term benefit of the program was evaluated by constructing a prospective expectation for each member of the medical class. Physiology grades obtained by past medical students were regressed on their undergraduate grades and MCAT scores. This regression model was used in a prospective manner to predict a physiology course grade for the entering class. Six of the seven summer program participants achieved scores equal to or higher than their predicted scores. Additionally, the regression model identified prospectively four of the six medical students who scored below 70% for the medical physiology course. This study suggests that a summer enrichment program can benefit participants.

Key words: minority students; basic science; preclinical studies; Medical College Admission Test; undergraduate grades

The Academic Support and Counseling Center (ASCC) at East Carolina University School of Medicine offers an 8-wk summer program to assist matriculating minority and disadvantaged students in preparing for the medical school curriculum (6). One component of this program is a 30-h Introduction to Physiology course.

In the past, this summer physiology course was structured around two or three introductory lectures from each of the physiology faculty, followed by a quiz on the material covered in lecture. Although this format provided a good overview of materials to be covered in the course, the quantity and breadth of information presented in the lecture were significantly less than in the actual course. This exposure, combined with examination questions that reflected the relative ease of the lectures, did not prepare the students with coping skills that could be used in the standard medical physiology course. The evaluation of the 1990 summer enrichment course by both the faculty and the students led to the following changes: 1) use medical level lectures when possible; 2) provide introductory lectures emphasizing common themes in physiology; 3) emphasize the development of listening and note-taking skills; 4) demonstrate some possible group study options; 5) review test questions, focusing on test item construction.

We believed that these changes would greatly increase the value of the course to the students. Consequently, these modifications were incorporated into the 1991 summer course, which would provide the students with academic skills necessary to succeed in the medical physiology course. The development of these skills should improve the level of student performance by the end of the summer,
and hopefully the skills would be retained until the medical physiology course is taken in the subsequent spring. Evidence of this effect required that appropriate evaluative techniques be developed and incorporated into the summer course.

Three independent mechanisms were used to evaluate the effectiveness of the new summer course. Student performance during the summer was compared with the average performance of the prior class of medical students on the same examination items. An improvement in examination performance over the summer (relative to the medical class average on the identical questions) was considered one indication of success. A second evaluation measured the long-term effects of the summer course. The performance of the summer students was monitored during the medical physiology course. The measure of success was based on the summer students performing better than expected from their admissions criteria (MCAT and undergraduate grades) (1–3, 7). A final evaluation surveyed the students at the end of the summer course and again at the end of the medical physiology course to gain insight into the perceived usefulness of the summer program.

The results from this study indicate that a summer physiology course, incorporating general academic skills, lead to a perceived improvement during the summer physiology course and in a subsequent medical physiology course. Incorporation of these skills in an introductory set of lectures in a medical physiology course may improve student performance in medical physiology.

METHODS

The 1991 Summer Physiology Course. 1) There were 18 lectures. The sequence of topics (with number of lectures in parentheses) was: Introduction (2), Cell (4), Acid-Base (5), Renal (5), and Respiratory (2). Nonlecture class meetings covered review of lecture notes (2), group study reviews of materials (3), examination/test-taking reviews (3), and in-class examinations (4).

2) Two introductory lectures were presented by the course director. In the first lecture, particular emphasis was placed on logic and cause-effect relationships. General comprehension skills involved the use and implications of equations and graphs as teaching aids. Common themes of osmosis and mass balance were treated in the second lecture.

3) Both the course director and the teaching assistant attended the lectures, and copies of the notes taken in class served as the focus for review sessions (three during class meetings and four others in addition to the scheduled class meetings). The first three examinations were followed by an in-course review of the concepts being examined and their location in the class notes.

4) During the review sessions, the students assumed responsibility for guiding the class through the lecture material on the basis of their individual class notes. Areas in which major points were unclear or totally missing from the student's notes were discussed, along with the student's reasons for assigning a lower importance to that information.

5) An examination followed each topical series of lectures, with the questions drawn from the first-year medical student examinations administered in the previous spring. This examination procedure allowed the summer students to compare their performance with medical class expectations. Additionally, in one session preceding the renal examination, the students constructed and evaluated their own questions. As noted above, the examinations were followed by a test review in which each question was analyzed individually.

Evaluation of student performance during the summer course. Examination items from the preceding year's medical physiology course were used to test the summer students. The item analysis based on the medical students' performance allowed the summer students to see the level of performance expected of the average medical student.

Evaluation of summer student performance during medical physiology. The intent of the summer course is to improve the participants' performance in the medical physiology course. This evaluation requires that student performance be compared with a predetermined standard. Consequently,
quantitative expectation was established for students at East Carolina University on the basis of seven of the admissions criteria [undergraduate grade point average (GPA) and six MCAT subtest scores]. Admissions data and the final grade in medical physiology for the class entering in 1990 (one year before the changes in the summer program) were subjected to a regression analysis. The regression equation \( y = a + bx \) was filled as course grade = intercept + (slope)(admissions criterion). This equation could then be solved for each student entering medical school, with the term-predicted grade substituted for the course grade. This process was repeated for each admissions criterion, resulting in seven independent predictions of the medical physiology course grade.

The predictions from the MCAT subtests were weighted according to the strength of the correlation (3, 7). The products of MCAT subscore X correlation coefficient were added to provide a summary prediction based on the MCAT scores. The summary MCAT-predicted grades were then normalized so that the means \( \pm SD \) equaled those for the actual physiology course grades. A new regression line was calculated for the summary MCAT prediction. The summary MCAT prediction was multiplied by the correlation coefficient and added to the product of the normalized GPA X GPA correlation coefficient. This new set of predicted grades was again normalized so that the means \( \pm SD \) equaled those for the actual medical physiology grades. The equations and process are summarized in APPENDIX A.

The regression analysis equations for the class entering in 1990 were used to predict the medical physiology course performance for each member of the class entering in 1991. These predicted grades provided the benchmark against which the actual performance of the class entering in 1991 could be evaluated. A significant improvement in the actual performance of the summer participants against the predicted performance from the admissions criteria would be evidence of a lasting effect from the summer experience.

Statistical analysis. Actual student medical physiology course grades were regressed against the MCAT subtest scores, GPA scores, and the predicted grades described above. A significant correlation is indicated by an \( r \) value > 0.23 (\( n = 70, P < 0.05 \)) or by an \( r \) value > 0.30 (\( n = 70, P < 0.01 \)) (5). The small sample size of students participating in the 1991 summer enrichment program (\( n = 7 \)) precludes any statistical analysis of their performance in medical physiology. Consequently, their grades are presented as qualitative information.

**Student evaluation of the course.** A questionnaire was administered at the end of the summer course to gain the students’ perspective of the usefulness of the changes in the summer program. The same questions were again administered after the regular medical physiology course, when the students could more accurately assess the skills necessary to succeed in medical physiology (see questionnaire reproduced in APPENDIX B).

**RESULTS**

Evaluation of student performance during the summer course. The summer students demonstrated a gradual improvement in scores as the course progressed (Table 1). By the end of the summer, the students were performing near the medical class average. This evaluation provides one positive indication of course efficacy.

**Accuracy of the estimated course grades.** The correlation between the MCAT subtests, under-

<table>
<thead>
<tr>
<th>Topic</th>
<th>Summer Students (( n = 7 ))</th>
<th>Medical Students (( n = 72 ))</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell (8)</td>
<td>64</td>
<td>81</td>
<td>-17</td>
</tr>
<tr>
<td>Acid Base (7)</td>
<td>67</td>
<td>78</td>
<td>-11</td>
</tr>
<tr>
<td>Renal (5)</td>
<td>78</td>
<td>80</td>
<td>-2</td>
</tr>
<tr>
<td>Respiratory (4)</td>
<td>82</td>
<td>90</td>
<td>-8</td>
</tr>
</tbody>
</table>

Questions (nos. in parentheses) used for comparison were selected from unsecured Medical Physiology examinations administered in the prior spring. Total examination length was 60 questions for the medical students and 15 questions for the summer program students. Summer students demonstrated a gradual improvement in scores compared with the medical student standard and were performing close to the medical class average level by the end of the course. This observation indicates one positive qualitative measure of course efficacy.
Scatter plot for MCAT subtest scores and undergraduate grade point average (GPA), illustrating the range of values for the class entering in 1990. Regression lines (dashed line, GPA; solid lines, subtest scores) for these criteria against the actual course grade in medical physiology are also shown, for which the following correlation coefficients apply: GPA, 0.47; biology, 0.30; chemistry, 0.30; physics, 0.32; vocabulary, 0.28; reading, 0.23; and quantitative, 0.32. All correlations were significant (P < 0.05). Data are presented with the predictive (independent) variables on the y-axis to allow plotting of MCAT and GPA on the same figure.

Graduate GPA, and the actual grades in medical physiology for the class entering in 1990 is shown in Fig. 1. This correlation was used to calculate an estimated grade for each student, as described in METHODS. Figure 2 shows the significant correlation between the estimated grade and the actual grades obtained by the class of 1990 in the medical physiology course (P < 0.01), reflecting the derivation of the equation. The estimated grades provide a useful, but far from perfect, reflection of the actual course grade, indicated by the correlation coefficient < 1.00 and the slope of the regression line. It is important to note that the relationship was maintained at the lower end of the grade scale.

Evaluation of 1991 summer student performance during medical physiology. The regression equation from the class entering in 1990 was applied to the admissions data for the class entering in 1991 (Fig. 3). This allows a prediction of the medical physiology performance to be made before the students begin the course. This analysis indicated that seven students were at risk for failing medical physiology, three of whom had been enrolled in the 1991 summer program.

At the end of the medical physiology course, the final grades for the class entering in 1991 were compared with the grades estimated from the 1990 equation. Figure 3 shows that the estimated grades
correlated significantly with the actual grades obtained in medical physiology ($P < 0.01$), indicating that the performance of one class can be used to predict the performance of a subsequent class.

The correlation was again accurate at the lower end of the grade scale. The equation predicted that seven students were at risk for failing medical physiology (predicted grade $< 70\%$), four of whom actually did fail. Conversely, of the six students who did fail medical physiology, four had been predicted to have difficulty.

The seven students who were enrolled in the 1991 summer program are identified in Fig. 3. Three of these students were predicted to have difficulty, but only one failed, and no students withdrew from the course. Six of the seven students scored at or above their predicted score. This was an improvement over the performance of past summer course participants. Of the ten students enrolled in the 1990 summer program, two students withdrew during medical physiology, three students scored $< 70\%$, and five students passed the medical physiology course.

The regression analysis was recalculated on the basis of data from the class entering in 1991 (Fig. 4). The correlation coefficients for the MCAT subscores and the undergraduate GPA differed from those of the previous year. These data were retrospectively to estimate the medical physiology course grade and the correlation of estimated grade with the actual grade obtained by the class of 1991 (Fig. 5). The composite regression equation yielded an $r$ value of 0.73 ($P < 0.01$) and appears to closely mirror data in Fig. 3.

**Student evaluation of the course.** Table 2 summarizes the rankings of summer physiology course components, a part of the student evaluation form (see APPENDIX B). Immediately after the summer course, the students assigned highest importance to the sessions identifying causality and two aspects of obtaining information from the lecture setting (note taking and identifying concepts in lecture). These three items also were ranked highest in the survey administered after the medical physiology course. It is interesting that the other rankings were similar in
TABLE 2  
Student ranking of summer physiology course components

<table>
<thead>
<tr>
<th></th>
<th>After Summer Program</th>
<th>After Medical Physiology Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause-effect relationships</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Note-taking skills</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Identification of concepts in</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>lecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student construction of</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>examination items</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equation manipulation</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Taking M-1 examinations</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Group study skills</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Teaching Assistant reviews</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Lectures</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Comparison of performance</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>with M-1 students</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

both surveys, with the notable exception of group study skills (increased in importance from 7th to 4th) and the student-designed examinations (dropped in importance from 4th to 8th).

Comments provided by the students after the summer course indicated a desire for additional emphasis on study skills (3), note-taking skills (1), causality (1), and identifying the important concepts in lecture (1). After experiencing the medical physiology course, the students indicated a desire for additional emphasis on identifying concepts (4), interpreting graphs, study group dynamics, and test-taking skills.

DISCUSSION

The most important conclusion from this study is that participation in a summer enrichment physiology course emphasizing basic academic skills improves the perceived performance in medical physiology the following spring.

Students who have difficulty in medical physiology often have one or more underlying academic deficiencies. Problems encountered in the past include difficulty in obtaining information from lecture, discerning cause from effect, interpreting graphs and equations, and test-taking difficulties. Appropriate academic skills are rarely taught explicitly at the medical school level. The summer enrichment program addresses each of these areas appropriately for a lecture-based course and provides the students with skills necessary to perform in medical physiology.

The ASCC at East Carolina University offers a summer enrichment program for matriculating medical students. Selection for this program is based on identification as a member of an ethnically, culturally, or financially underrepresented group. This program also offers the opportunity to make curricular interventions in a subgroup of the medical class, with the remainder of the medical class acting as controls for the study. Assessment of student performance was made by the ASCC as the summer course progressed and separately at the end of the medical physiology course.

The in-course evaluation matched summer student performance on examination items against the performance of the previous class of medical students on the same items. The summer students showed a gradual improvement in performance during the summer compared with performance of the medical class on the same questions. The sequence of topics was identical in both the summer and the Medical Physiology course. Inclusion of new questions in each examination indicated that the students were not inappropriately using a copy of the M-1 examination as a study aid.

There are some limitations to comparing the summer student performance with performance of medical students on identical questions. The examination questions selected for the summer students were limited because of their lack of background information. For example, cardiovascular physiology was not covered in the summer course but formed a basis for some respiratory and renal blood flow questions used in the medical course. Additionally, the respiratory section covered only two lectures. The examination questions could be selected only from this introductory material, so the medical student average was unusually high. The difference between the summer students and medical students was consequently high, despite an overall good performance by the summer students.

It is difficult to draw any conclusions about student performance in the upcoming medical physiology
course at the end of the summer program. Some uncontrolled factors favor a higher examination performance in the summer program, including few lectures covered on each examination and ready access to a course teaching assistant. Other factors, however, favor a lower performance on the summer examinations, including a lack of motivation in a summer course, the fact that the test scores do not count toward a course grade, and the lack of background information from topics to be covered in the M-1 curriculum.

The most appropriate evaluation of the summer program would measure the performance of the summer participants in the medical physiology course. Because of the heterogeneous sample, a method for predicting individual performance in the medical physiology course had to be determined. This would allow the actual grade for each student to be compared with a predicted grade. A performance better than predicted would provide evidence that the summer course had a beneficial effect.

The regression prediction from the 1990 equation and the 1991 admissions scores proved reliable. This is important, because it indicates that the admissions criteria can be used to identify students who are at risk in certain subjects, even before the school year begins. Such information may be used by the Office of Student Affairs to ensure that appropriate support is available for these individuals.

East Carolina University School of Medicine educates a diverse student body. The school seeks to increase access to health professions for ethnic minorities and to increase the number of physicians in the primary care specialties. Consequently, academic potential is not the only factor weighed in the admissions process. The diversity of the students may contribute to the significant correlations between the MCAT and GPA and the basic science grades (physiology, in this case).

Academic performance in medical school is influenced by a variety of factors, not all of which are related to academics. The results from this study must be interpreted cautiously because, like that at most schools, curriculum revision in our school is an ongoing process.

An additional fact has prevented the use of this approach for the class entering in 1992. The MCAT report has been revised and now provides only four scores. Consequently, the equation developed for the class entering in 1991 could not be applied to the class entering in 1992. More background data must be collected before further evaluation of the summer course will be possible.

In summary, participation in a revised summer physiology course has produced short-term (2-month) and long-term (1-year) improvement in student performance. The ability to identify students who are at risk for academic troubles may allow a proactive, rather than reactive, approach to teaching physiology. Some of the revisions listed may be appropriate for inclusion in the introductory lectures in a medical physiology course.

APPENDIX A

Prediction of Physiology Grade From MCAT Subtest Scores and Undergraduate GPA

1) For one class, regress each MCAT subtest score and GPA against the medical physiology course grade. Record the correlation coefficients.

2) For each student, calculate a weighted score for each MCAT subtest, and add the weighted subtest scores for a weighted MCAT score. (Process is shown for correlations from the East Carolina Univ. class of 1990.)

3) Normalize the weighted MCAT score so that the values have the same means ± SD as the class of 1990 Medical Physiology course grades.

\[
\text{weighted MCAT} = \frac{\text{weighted subtest score}}{\text{correlation coefficient}}
\]

\[
\text{weighted subtest score} = \sum (\text{MCAT subtest score} \times \text{correlation coefficient})
\]

\[
\text{weighted MCAT} = \frac{\text{weighted subtest score}}{\text{correlation coefficient}}
\]

\[
\text{weighted MCAT} = \frac{\text{class of 1990 mean grade}}{\text{weighted 1990 MCAT mean}}
\]

\[
\times \frac{\text{class of 1990 SD}}{\text{weighted MCAT SD}}
\]
4) For the entire class, regress the normalized MCAT against the class medical physiology course grade. Record the correlation coefficient.

5) Normalize the undergraduate GPA

\[
\text{undergraduate GPA} \times \frac{\text{class of 1990 mean grade}}{\text{undergraduate GPA mean}} \times \frac{\text{class of 1990 SD}}{\text{undergraduate GPA SD}}
\]

6) For each student, weigh the normalized GPA and the normalized MCAT by multiplying them by the appropriate correlation coefficient, and add the results

\[
\text{normalized GPA} \times 0.47 = \text{weighted GPA} \\
\text{normalized MCAT} \times 0.52 = \text{weighted MCAT}
\]

7) Normalize the predicted scores to reflect the class mean ± SD

\[
\text{weighted predicted grade} \times \frac{1990 \text{ class mean}}{\text{predicted grade mean}} \times \frac{\text{predicted grade SD}}{\text{1990 class SD}}
\]

8) This process can be applied prospectively, replacing the MCAT and GPA scores with scores from the incoming class, but retaining all other values from the class of 1990.

**APPENDIX B**

**ASCC Summer Physiology Course Evaluation**

Accurate information about your experiences this summer will help to improve the utility of this preparatory course. Please answer the following questions, and be honest about it.

**Lecturers.** Rank the following lecturers according to all categories. Use a 1- to 10-point scale, with 1 = poor, and 10 = exceptional.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Cell</th>
<th>Acid-Base</th>
<th>Renal</th>
<th>Resp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphasis on important points</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Organization of material</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Clarity of presentation</td>
<td>9</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall lecturer effectiveness</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
</tbody>
</table>

**Instructors**

Review sessions. Again, use the 1 to 10 scale.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Cell</th>
<th>Acid-Base</th>
<th>Renal</th>
<th>Resp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarified concepts</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Response to questions</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Overall rating of effectiveness</td>
<td>9</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Course design.** Rank the following activities according to perceived usefulness, with 1 = useless and 10 = exceptionally useful.

Attending lectures
Evaluation of note-taking skills
Identifying concepts in lectures
Student construction of exam questions
Taking M-1 examination questions
Comparison of class performance to M-1 standards
Focus on cause-effect relationship in graphs
Manipulation of algebraic equations
Study group dynamics
Teaching Assistant review sessions

**Which activities should be deleted from next year’s course?**

**Which activities should have additional emphasis in next year’s course?**

Thanks for your help with this evaluation and your efforts over the course.

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**References**


